SYNOPSIS

"Studies on Pristine and Doped Manganese Oxides for its Application"

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1. Introduction

Semiconductors have the distinct ability to serve as an insulator or conductor depending on the surrounding environment. The properties of a semiconductor can be affected by temperature, light, electric currents, or even electric fields. The conductivity of an elemental semiconductor is determined by the number of valence electrons in its electron shell. Because of this peculiar property, semiconductors are crucial to current technology. Integrated circuits, transistors, solar cells, and many other computing materials would not exist without semiconductors. Consequently, semiconductor materials have a substantial impact on the supply chain for electronic products. Scientists have made significant advances in semiconductor innovation in recent decades. Moore's Law, which asserts that the number of circuits on a microchip doubles every two years, has been regularly followed by researchers. They were able to do so by experimenting with different semiconductor materials (1).

The advancement in the modern technology requires the fabrication of ultra-small gadgets and devices which are faster, more flexible, perform better, and cost effective. As a result of this, new technologies and materials have been developed to meet the needs of the growing semiconductor industry. Nanotechnology is one of the most current and dynamic fields of research in which gadgets are made up of very small particles having unique characteristics. Thin-film technology, which allows for the deposition of extremely thin layers of solid material on a supporting substrate, is crucial in this regard. Because of their wide band gap, metal oxide semiconductor (MOS) thin films have been used in a range of applications, including near-UV light emitting diodes (LEDs), gas sensors, solar cells, non-volatile memory, and optoelectronic devices (2). Manganese oxide is any of a variety of manganese oxides and hydroxides. These include, Manganese(II) oxide or Ferrite Grade(MnO), Manganese (II,III) oxide (Mn_3O_4), Manganese(III) oxide (Mn_2O_3), Manganese dioxide or manganese(IV) oxide (MnO_2), Manganese(VI) oxide (MnO_3), Manganese(VII) oxide (Mn_2O_7) and Other manganese oxides include Mn_5O_8, Mn_7O_{12} and Mn_7O_{13}.

Manganese oxides are one of the most widely studied metal oxide catalyst, due to its durability, flexibility, low toxicity, and low cost. Manganese oxides are versatile, it can form different crystal phases and oxidation states, this enable it to store oxygen effectively MnO_2 is

one of several metal oxide semiconductors used in dry cell batteries, such as alkaline and Leclanché cells, which are zinc–carbon batteries. Approximately 500,000 tonnes of MnO_2 is consumed every year for this application. MnO_2 is used as an inorganic pigment in ceramics and glassmaking, among other applications. Cell capacity is primarily determined by the type and quantity of manganese dioxide (MnO_2) employed in dry cells. Individual crystal structure, different degrees of hydration and manganese dioxide activity are the factors that influence the performance. The pH of the electrolyte has an impact on manganese dioxide potential. Cathode capacity is limited in most zinc–carbon batteries (2).

2. Review of Literature

Manganese Oxides are a low-cost, commonly available material that is employed as a solid cathode in primary liquid cells all over the world. Significant progress has been achieved in the development of new synthetic Manganese oxides, phases in recent years (3). Because dopants can change the energy band structure, morphology, and surface to volume ratio, create more active centres at grain boundaries, and produce defects and vacancies, doping is the most effective technique for increasing the structural, optical, and electrical properties of the pure form material. Transition metals such as Nickel (Ni), Manganese (Mn), Iron (Fe), Cobalt (Co), and Titanium (Ti), etc. have been demonstrated to be effective dopants, as have Ruthenium (Ru), Erbium (Er), and Cesium (Ce) (4) (5).

3. Objective of proposed work

• To prepare pristine and doped nanomaterials of one of the Manganese Oxides.

• To investigate the structural properties, morphological and optical of pure and doped one of the Manganese Oxides nanomaterial and its application.

4. Synthesis methods

There are several methods which are required for the synthesis of metal oxide (physical, chemical, and biological methods), hydrothermal method, the sol-gel method, flash spray pyrolysis, polyol synthesis, electro-spraying, chemical vapour deposition, inert gas condensation, micro emulsion technique, pulse vapour deposition, laser pyrolysis, electro

deposition, chemical exfoliation, and others. I plan to synthesise one of the family of manganese oxides using a chemical route or solid state reaction route.

5. Experimental section

In the experimental part, first produce metal oxide using the above methods, and then characterise materials by probing and measuring their structure and properties. It is a crucial step in material science without which no scientific understanding of engineering materials could be established. Characterization can be classified on a microscopic, macroscopic, or spectroscopic basis. Microscopy is a group of characterization techniques that probe and map a material's surface and subsurface. Some typical microscopy instruments are: 1) optical microscopy 2) SEM (scanning electron microscope) 3) TEM (Transmission Electron Microscopy) 4) FIM (Field Ion Microscopy) 5) STM (Scanning Tunneling Microscope) 6) SPM (Scanning Probe Microscope) 7) AFM(Atomic-force microscopy). Second, the spectroscopy group of techniques uses a variety of principles to identify a material's chemical composition, composition variation, crystal structure, and photoelectric qualities. 1)Ultraviolet-Visible Spectroscopy 2)FTIR (Fourier-transform infrared spectroscopy) 3)TL 4)PL 5)XRD (X-ray powder diffraction) 6)SAXS 7)EDX 8)WDX 9)EELS 10)XPCS 11)AES 12)XPS. Mechanical testing, including tensile, compressive, creep, fatigue, and hardness testing, is among the many procedures used to assess various macroscopic properties of materials. DTA, DETA, and TGA are the acronyms for the following: 1) DTA, 2) DETA, and 3) DSC 4) LET are a few examples. All of the characterization approaches discussed above are quite valuable for determining the material structure and properties. As a result, consider every potential characterization.

6. National and International status

Significant progress has been achieved in the development of new synthetic manganese oxides' phases on national and international level few of them are listed below. Nanostructured Manganese oxideshave admirable chemical stability, transparency, low toxicity, low cost, functional biocompatibility, excellent adsorption capacity, catalytic properties, and widespread availability. Thin films of Manganese Oxides are widely used in bio-sensors (6) (7), gas sensors (8), catalysis, electromagnetic wave-absorbing layers, and high-performance electrochemical electrodes and energy storage (9) (10) (11). The presence of the dopants plays a crucial role in improving the chemical and physical properties of

manganese oxides thin films. A good number of research work have been done on the synthesis and characterization of Al, Ag, Co, and Cr, etc. doped Manganese oxides nanomaterial (13) (14) (15). Supplementary to these metals, Cu has a great deal of diligence dopant because of its low cost, good electrical conductivity, non-toxicity and environment friendly nature (16). Different methods have been engaged to fabricate nanomaterials of Manganese oxides via hydrothermal technique (17), Sol–gel technique (18), electrochemical deposition method (19), reduction process (20), and spray pyrolysis technique (21) (22). Very few reports are available on Cu doped Manganese oxides' nanomaterials which are well discussed on gas sensing and biosensing application (23).

7. Motivation

Thin films have drastically different characteristics than their bulk materials. Thin films based on semiconductor metal oxides (SMOs) have been extensively used due to their distinct optical and electrical properties. Among all the SMOs, undoped Manganese Oxides are semiconductor with the Fermi level inside the band gap. The band gap is 1.33 eV (24). Further when Manganese Oxides are doped with suitable dopants, its structural, morphological, optical, electrical as well as gas sensing properties enhanced. Such types of films then considered as one of the prominent candidates in various of applications like in bio-sensors (6) (7) gas sensors (8), catalysis, electromagnetic wave-absorbing layers, and high-performance electrochemical electrodes and energy storage (9) (10) (11)etc.

8. Hypothesis/ Assumption

Fe, Ni and Co etc. are often doped into Manganese Oxides matrix to alter its optical, electrical, and ferromagnetic characteristics. So, the proposed work is planned to prepare one of the pure and doped nanomaterials of Manganese oxides and study the influence of doping on its characteristics.

• The research work is directed to obtain new and improved pure and doped one of the family of Manganese Oxides nanomaterials.

• The enhancement in morphological and optical properties of pure Manganese oxides will be expected after doping.

• The sensing performance like selectivity, sensitivity, response and recovery time of SMOs films will improve with doping.

9. Year wise plan of work and targets

First year

In first six months, will complete Course work and after Six months will undertake literature review on pure and doped nanomaterials of the Manganese oxides. Chemical and other experimental materials will be collected and assembled. Preparation and characterization of pure and doped Manganese oxides nanomaterials.

Second year

In second year, structural, optical and electrochemical characteristics to develop oxide nanostructures will be considered by various means. The pure and doped one of the Manganese Oxides nanomaterials will be prepared and checked their properties by using different characterization techniques for eg. XRD, SEM, UV-VIS, EDAX and its application.

Third year

In the third year, the research paper will be published in journals. Also, the outcomes of the research work will be presented in national and international conferences, seminars etc. Finally, the thesis for the Doctoral degree will be written.

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